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A SIMPLE POLICY PLANNING MODEL FOR DETERMINING SEA AND SHORE TOUR LENGTHS

Richard W. Butterworth

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A SIMPLE POLICY PLANNING MODEL FOR DETERMINING SEA AND SHORE TOUR LENGTHS

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The periodic rotation of enlisted personnel between sea duty and shore duty assignments is a firmly established Navy policy. The efficiency with which the rotation process is managed, however, can have an effect on both the personnel readiness of operating units and morale of the individual Navy man. This study is part of a larger research program to develop computerized models of the rotation process to provide rotation managers in the Bureau of Naval Personnel with a quantitative basis for decisions and the capability to test and evaluate rotation policy.

20. ABSTRACT (Continued)

In this report a simple model for determining nominal tour lengths which would keep the sea and shore populations in balance is presented. It differs from previous models developed within the research program in that a different set of assumptions are made, and different data are required for using the model. In the conclusions, the applications and limitations of this model are discussed as well as some ideas on what future research might be done on the sea/shore rotation problem.

SUMMARY

Problem

The movement of enlisted personnel between sea and shore billets is an established policy in the Navy. One primary goal of sea/shore rotation management is to provide adequate numbers of personnel in the sea and shore communities at all times. Another goal is to provide a variety of duty assignments for the career enlisted force, including both sea and shore type assignments. Problems in rotation management result from trying to achieve these goals in a dynamic environment where manpower requirements, personnel levels, and operational commitments are changing.

Background

This study is part of a larger effort by the Navy Personnel Research and Development Center aimed at the development of computer based tools and techniques for application in the Bureau of Naval Personnel (BUPERS) to help improve the management of the enlisted rotation system. This effort has resulted in a series of computerized models which have been used in BUPERS in various planning or policy testing applications.

Approach

The primary emphasis throughout this effort has been on the development of models which would provide BUPERS rotation managers with a quantitative basis for their decisions and a capability to test and evaluate policy and procedural options related to the planning and control of personnel movements.

Findings and Conclusions

This report describes a simple model for determining nominal tour lengths which would keep the sea and shore populations in balance. The model was developed within the general framework described above. It differs, however, from the previous models developed in that a different set of assumptions are made and different data are required for using the model. For the purposes of policy determination and long-range planning, an approximate approach which accounts only for the first order effects is appropriate. For this application, the model would be suitable.

The typical crisis that a rotation manager must deal with, however, seems to be an under or over manning in the sea or shore community. Presently, the rotation system provides no method for the manager to look ahead and view the probable effects of his actions. It seems then that a model which would forecast the sea and shore manning levels up to, say 5 or 6 years ahead, based on the current inventory of personnel and the probable policy to be followed in the next 2 to 3 years, would be a useful tool to the rotation manager.

Such a model would have several uses. The rotation manager could use the model for feedback to his decision-making process. This would give him an opportunity to intelligently assess the probable effect of his current actions. In addition, future manning problems could be predicted and corrective action could be taken. Finally, various short-term policies could be tested to determine their impact on the rotation system.

PREFACE

This study was part of a cooperative effort between the Navy Personnel Research and Development Center, San Diego, California, and the Naval Postgraduate School, Monterey, California.

Mr. Robert P. Thorpe, Navy Personnel Research and Development Center, was Program Director; Richard W. Butterworth, Assistant Professor of Operations Research, Department of Operations Research and Administration Sciences, Naval Postgraduate School, was the Principal Investigator.

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PROBLEM

The movement of enlisted personnel between sea and shore billets is an established policy in the Navy. Under this policy, the career enlisted man can expect to be in a shore based job at times, and a sea based job at other times. One primary goal of sea/shore rotation management is to provide adequate numbers of personnel in the sea and shore communities at all times. Another goal of rotation management is to provide a variety of duty assignments for the career enlisted force, including both sea and shore type assignments. Problems in rotation management result from trying to achieve these goals in a dynamic environment where manpower requirements, personnel levels, and operational commitments are constantly changing.

BACKGROUND AND PURPOSE

Research into the sea/shore rotation problem has taken several forms. In references (1) and (2), the Navy's SEAVEY planning system was studied. In this system, personnel were given an opportunity to move to shore as existing shore tours expired and vacancies in shore billets became available. While this rotation method would appear to be feasible, there were problems in the implementation of the procedures. (See (3), page 4)

Current procedures are being directed towards determining a tour length at the inception of the man's tour. Under this system, personnel rotation between the sea and shore populations is driven by the expiration of tour lengths as well as by promotion and attrition. The need to maintain an adequate manning strength requires, in some cases, that an assigned tour length be changed. This has occasionally caused some uncertainty in the individual's plans.

Methods for determining what the normal tour lengths should be are the subject of references (3) and (4). The goal there is to determine the tour lengths which would keep the sea and shore populations in balance for each rating over the long run.

Reference (5) describes a simulation model of the rotation process, using data from the Bureau of Naval Personnel files. This model is designed primarily to describe the short run fluctuations in sea and shore manning and to determine the adjustments in existing tour lengths necessary to correct these fluctuations. Reference (6) is also a simulation model utilizing the Bureau of Naval Personnel data.

This model evaluates the performance of a hypothetical rotation policy for which the tour length is initially determined to the nearest quarter (3 months). When the tour has 4 quarters remaining prior to expiration, a specific month for rotation is chosen and not allowed to change. This policy would reduce the uncertainty to the individual while limiting the flexibility of the rotation manager.

In this paper, a simple model for determining nominal tour lengths which would keep the sea and shore populations in balance is presented. It differs from the model presented in (3) and (4) in that a different set of assumptions are made, and different data are required for using the model. In the conclusions, the applications and limitations of this model are discussed as well as some ideas on what further research might be done on the sea/shore rotation problem.

MODEL FORMULATION

The problem which this model is intended to address is that of choosing tour lengths for sea and shore tours within any given rating which will, over the long run, maintain a stability or balance between the sea and shore populations.

As most ratings correspond to job skills which are most appropriate for either shipboard or land based jobs, there is usually a large difference between the number of sea duty and shore duty billets in each rating. For example, in the Boatswain's mate rating, there are about 7300 sea duty billets and only 3200 shore duty billets. A sea to shore billet ratio between 2 and 3 is typical for ratings corresponding to the shipboard skills. The Data Processing Technician rating has sea billet requirements of about 950 and shore billet requirements of about 2200. In this case, the imbalance in requirements between sea and shore type duty favors the shore duty.

To maintain a balanced flow of personnel between sea and shore type duty, it is necessary to require longer tours for the type duty that requires the largest number of personnel. As a first approximation, to maintain an equilibrium flow of personnel, the ratio of sea duty strength to sea tour length should equal the ratio of shore duty strength to shore tour length for a rating. This would imply that the net flow of personnel per unit time between sea and shore type duty is zero, a condition for equilibrium.

The above approach of requiring a net personnel flow of zero out of the sea and shore type duty groups as a condition for equilibrium is basic to the model developed here. The above method needs modification, however, to account for the effects of attrition out of the rating and promotion within the rating.

The billet requirements within each rating can be segregated by rate (i.e. pay grade) and type of duty (i.e. sea or shore). A promotion into a different rate within the rating then implies that the individual's opportunity for sea/shore rotation has possibly changed since the individual is, to some degree, constrained to rotate into a billet of his new rate. It would be virtually impossible, however, to maintain an equilibrium flow of personnel within each rate of rating. This is because the ratio of sea to shore billets for each specific rate in a rating varies considerably over the rates, and it is not administratively feasible to have the corresponding tour lengths vary between each rate as well. This problem is alleviated in practice by grouping the rates within a rating and treating the group as homogenous for rotation purposes. The grouping suggested is E-4 and below, E-5 and E-6, and E-7 to E-9. This grouping was suggested by the apparent practice of using nominal tour lengths which are the same for each rate in these groups, and vary only between groups.

The attrition from a rating for any reason also complicates the simple billet to tour length ratio approach mentioned above. It is not a closed system at all since those entering do not take the position of those leaving. Consequently, some allowance for attrition must be made in determining the conditions for an equilibrium flow.

We have, as described above, grouped the rates within each rating into E-4 and below, E-5 and E-6, and E-7 to E-9. For rotation purposes, the groups are considered to be homogenous. These definition of groups could certainly be changed, however, any grouping used should have a consistent tour length policy within the group. These groups are further divided into sea and shore type duty, except for the E-4 and below group. This latter group is considered to be non-career personnel who provide the input to the career force, and as such, the benefits of sea/shore rotation are not generally made available to them. The above definitions might vary between ratings.

Attrition from the groups is compensated for in determining the conditions for equilibrium. In this context, it is assumed that attrition accounts for all losses from the rating, including transfers into officer programs for example.

Some further modeling assumptions made are that the attrition from the E-7 to E-9 group forms the requirements for promotion into this group, keeping the group's size constant. The attrition and promotion from the E-5 and E-6 group is also assumed to set the requirements for promotion into the group. These two modeling assumptions could be replaced by allowing for a given expansion or contraction of the rating if necessary.

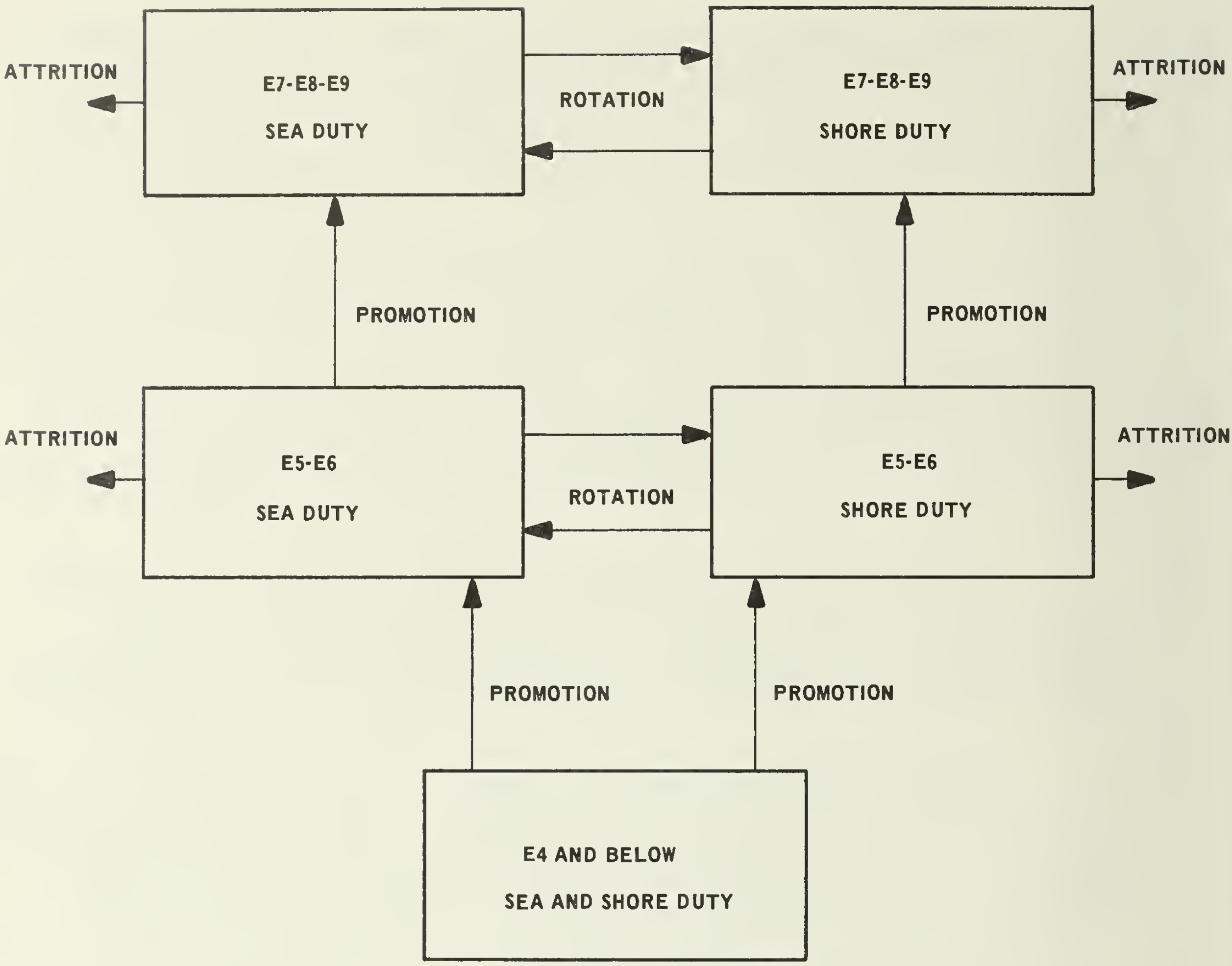

Figure 1. Personnel Flow For Sea/Shore Rotation Model

The above diagram shows the personnel flows that are accounted for in our model. A mathematical characterization of the conditions for equilibrium are discussed below. Essentially, we want to require that the net personnel flow out of any of the top four groups shown in Figure 1 is zero. The E-7 to E-9 groups (i.e. sea and shore) can be viewed independently of the E-5 and E-6 groups, as shown below. Either the E-7 to E-9 or the E-5 and E-6 rate groups could be the XYZ rates represented in Figure 2 below.

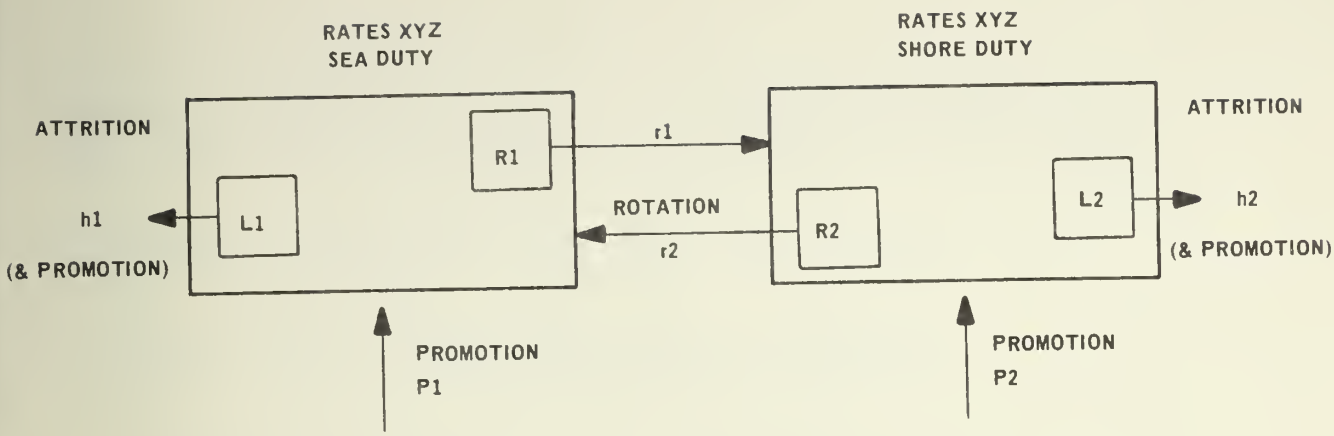

Figure 2. Personnel Flow Rate For Either Rate Group Within A Rating

A precise definition of the sub-populations L and R indicated in Figure 2 as well as the parameters h, r, and p are given as follows:

L_i = number of personnel in type duty i who are destined to leave the system in Figure 2 without further rotation. These leavers could be promotions or attrition (or both).

R_i = number of personnel in type duty i who are destined to rotate before leaving the system in Figure 2.

$N_i = L_i + R_i$ = total strength of type duty i

where i = 1 for sea duty, and

i = 2 for shore duty.

Note that everyone in type duty i is assumed to belong to either L_i or R_i, but not both. It is not necessary to formally identify the individuals within a subpopulation to apply the model, but only to estimate how many there are in each.

h_i = loss rate in personnel per month from subpopulation L_i, to be estimated from loss data on the rating.

r_i = rotation rate in personnel per month from subpopulation R_i, to be determined by the model.

p_i = promotion rate in personnel per month into type duty i, assumed known.

Note that as described above, we will assume that the overall size is not changing by assuming $h_1 + h_2 = p_1 + p_2$. This could be modified to account for a planned expansion or contraction of the rating. Some further definitions are necessary to describe our model.

TL_i = average time in months spent in subpopulation L_i, to be estimated.

TR_i = average time in months spent in subpopulation R_i, to be determined by policy and the model.

where i = 1 for sea duty, and

i = 2 for shore duty.

Note that TR_1 is the nominal sea tour length and TR_2 is the nominal shore tour length for the rating. The TL_i parameters can be estimated by assuming that most personnel will not be rotated if they don't anticipate spending at least half of the following tour on duty before leaving. As a first approximation, one can then use $TL_i = TR_i$, or an estimate of TR_i. See the next section on model modifications and limitations for more discussion of parameter estimation.

To apply the conditions for equilibrium within the rotation system, the standard formula which says that the number of personnel in a population equals the flow rate into the population times the average time spent in the population is used.

The basic equation necessary for long-run equilibrium between the sea and shore populations is:

$$p_1 + r_2 = h_1 + r_1 \qquad (1)$$

This equation, with our assumption that $p_1 + p_2 = h_1 + h_2$, is equivalent to requiring that the personnel flow into each population must equal the flow out.

Now suppose that we want to pick a value for the shore tour TR_2 and determine the necessary sea tour TR_1. First, compute L_2 from

$$L_2 = h_2 \times TL_2 \qquad (2)$$

Since N_2, the total shore duty strength for the rates under study, is usually known, compute R_2 from

$$R_2 = N_2 - L_2 \qquad (3)$$

The rotation rate r_2 is simply

$$r_2 = R_2/TR_2 \tag{4}$$

Apply equation (1) to find

$$r_1 = r_2 + h_2 - p_2 \tag{5}$$

Using the estimate of h_1 and TL_1 we have

$$L_1 = h_1 \times TL_1 \tag{6}$$

and $R_1 = N_1 - L_1$ (7)

It follows that to produce the rotation rate r_1 computed for equilibrium, we need

$$TR_1 = R_1/r_1 \tag{8}$$

The procedure could be worked in reverse, specifying a value of the sea tour length TR_1 and computing the value of shore tour length TR_2 implied by the conditions for equilibrium.

NUMERICAL EXAMPLE

The following numerical example will illustrate the computational procedure. Suppose that

N_1 = 5,000 personnel needed for sea duty

N_2 = 2,000 personnel needed for shore duty

h_1 = 20 personnel per month loss to sea population

p_1 = 10 personnel per month promoted to sea population

h_2 = 10 personnel per month loss to shore population

p_2 = 20 personnel per month promoted to shore population

TL_1 = 24 months average sea duty for leavers

TL_2 = 15 months average shore duty for leavers

Now suppose the shore tour policy is TR_2 = 24 months. From (2) we have $L_2 = 10 \times 15 = 150$ personnel. From (3) we have $R_2 = 2{,}000 - 150 = 1850$ personnel. From (4) we see $r_2 = 1850/24 = 77$ personnel per month. Applying the equilibrium condition of (1) we have $r_1 = 77 + 10 - 20 = 67$ personnel per month necessary for stability.

Using (6) and (7) we now have $L_1 = 20 \times 24 = 480$ personnel so that $R_1 = 5{,}000 - 480 = 4{,}520$ personnel. Finally, by (8), the resulting sea tour length is $TR_1 = 4520/67 = 67.5$ months.

Note that if the effects of promotion and attrition are ignored by using the formula

$$TL_1 = TL_2 \times (N_1/N_2) \tag{9}$$

referred to earlier, the resulting computed sea tour length would be $TL_1 = 24 \times 5/2 = 60$ months, some 7.5 months short of the above calculation.

MODEL MODIFICATIONS AND LIMITATIONS

One modification possible on this model would be to allow for a planned expansion or contraction of the rating. In this case, equation (1) becomes

$$P_1 + r_2 = h_1 + r_1 + c_1 \tag{10}$$

and $$P_2 + r_1 = h_2 + r_2 + c_2 \tag{11}$$

c_i = planned change in personnel per month for type duty i.

i = 1 for sea duty, and

i = 2 for shore duty.

Note that $c_i > 0$ corresponds to an increasing group and $c_i < 0$ a decreasing group size.

The parameters h_i and TL_i may be difficult to estimate in practice. Their only use is to estimate the size of the subpopulation of leavers, L_i. It may be easier (and more accurate) to estimate L_i directly, and use these estimates in lieu of (2) and (6).

The above model is a particularly simple approach for determining a policy planning value of sea and shore tour lengths. It does not reflect the detail of the actual rotation process, and is not meant to. For the purposes of policy determination and long-range planning, an approximate approach which accounts for the first order effects only is appropriate. For this application, the model would seem to be suitable. While a precise estimation of some model parameters may be difficult, an exact estimate is not really needed, as the application is only approximate.

The primary limitation of the model occurs because the equilibrium conditions are, of necessity, steady state in nature. All the transient influences introduced by fluctuations in the input and assignment process are ignored. While any consistent policy determination can not be allowed to depend on this transient turbulence, the operational problems of rotation management are very much driven by these fluctuations. The point being made here is simply that no policy planning model can address what may be the greatest operational problems of rotation management.

The concluding section of this report contains some thoughts on another model which might be useful in the operational problems of rotation management.

THOUGHTS ON FUTURE RESEARCH

As discussed in the preceeding section, the operational problems of rotation management are driven primarily by fluctuations and transient effects in the rotation system. Specifically, the solution to the immediate problems of under or over manning at sea or shore taken by rotation managers can be somewhat drastic. The entire input of personnel may be temporarily diverted to correct a local problem. The rotation managers themselves have usually rotated to another job before the consequences of their actions become apparent.

The typical crisis that a rotation manager must deal with seems to be an under or over manning in the sea or shore community. Presently, the rotation system provides no method for the manager to look ahead and view the probable effect of his actions. It seems then, that a model which would forecast the sea and shore manning levels up to, say 5 or 6 years ahead, based on the current inventory of personnel and the probable policy to be followed in the next 2 to 3 years, would be a useful tool to the rotation manager.

In principle, the information necessary to make these forecasts is readily available. The current inventory of on-board personnel is known. Since tour lengths are mostly two years or more, most of the rotational moves (split-tour moves not included) for two years ahead are already known. A statistical compensation for attrition could be made as well. By specifying the tour length policy for the next several years, as well as any predictable special events (creation of a new rating, large changes in billet requirements, etc.), one could forecast manning levels up to 4 and perhaps 5 or 6 years ahead. Rather than a single prediction, such a model should give a confidence interval (i.e. range of values) in which the manning levels could be expected to fall.

A model as described above would have several uses. The rotation manager could use the model for feedback to his decision-making process. This would give him an opportunity to intelligently assess the probable effect of his current actions. In addition, future manning problems could be predicted and corrective action could be taken. Finally, various short-term policies could be tested to determine their impact on the rotation system.

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